National Site Assessment Symposium Training Program
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Assessment Strategies for PFAS
Case Study for the Blades Groundwater Site

U.S. EPA, Region 3

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Discuss Blades, DE, describe geographical setting

Objectives:
The aim of the investigation was to identify strategies for EPA and stakeholders to extend best methods and testing for PFAS releases and to establish a plan with strategies and best management practices for data collection.

Focus areas for this Site Inspection: regulation, mapping and geospatial data, including fate, transport and toxicology,

Site Assessment Factors

- Regulation
  - U.S. Environmental Protection Agency (U.S. EPA) drinking water lifetime health advisory for PFOA and PFOS - 70 ppt
  - The State of Delaware has designated PFOA and PFOS hazardous substances as of July, 2018.
- Mapping/Geospatial
  - Extent of potential affects. Maximum concentrations and magnitude of affect.
  - Lithological layers - higher permeability units, confining units.
  - Affected wells, affected rivers and wetlands i.e. (Targets and Receptors)
- Fate
  - PFASs is highly water soluble with weak soil sorption and exhibit recalcitrance to natural degradation, leading to the potential for large but narrow groundwater plumes.
- Transport
  - Transport in sandy lithological layers and higher permeability units and confining units.
  - PFAS compounds flow readily with a density close to water.

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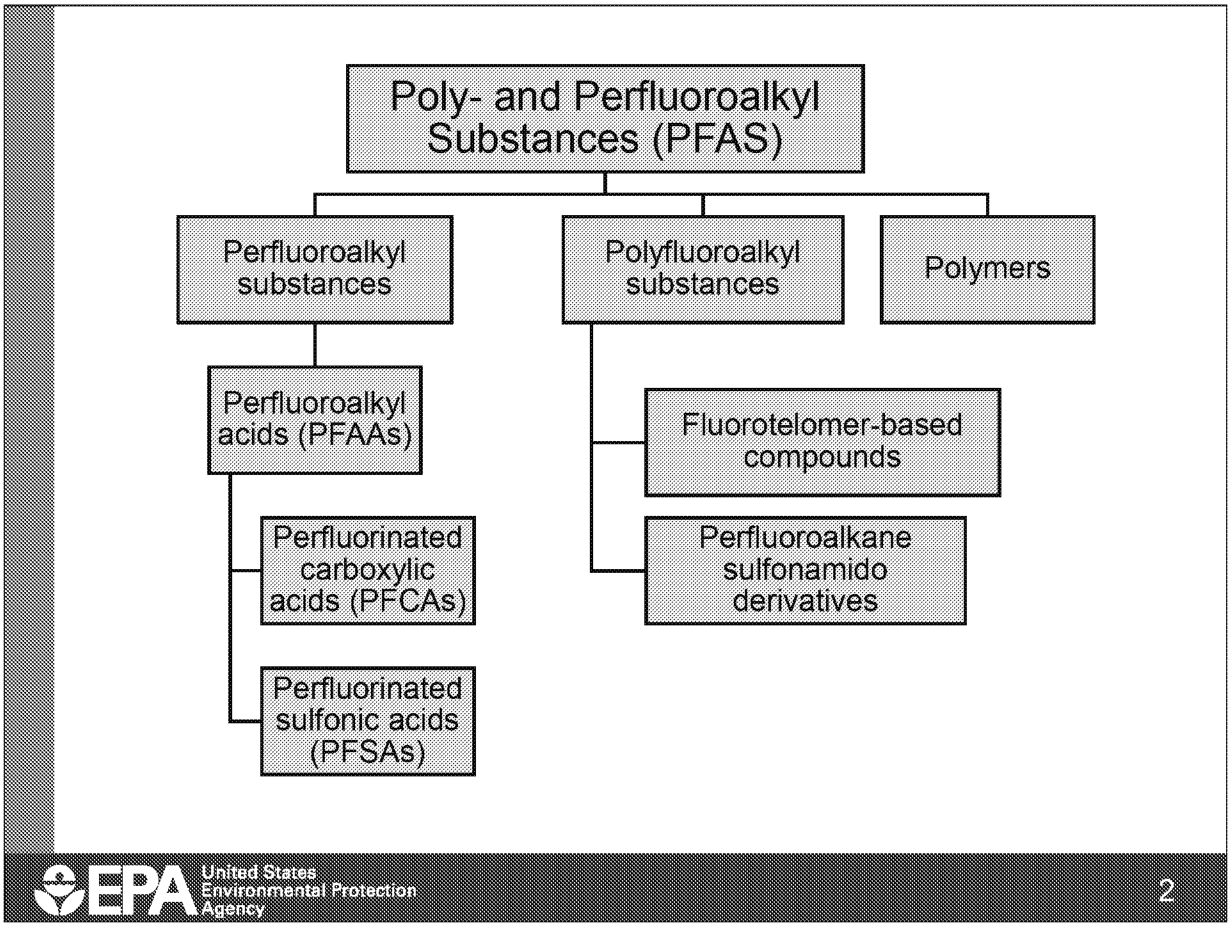
-Focus areas: mapping/geospatial, including fate, transport, toxicology, and regulation
-In particular, there is still considerable uncertainty regarding human health impacts of PFASs.
-Frameworks sequentially evaluating exposure, persistence, and treatability can prioritize PFASs for evaluation of potential human health impacts.
-This site-wide case study illustrates how geospatial and standard investigatory methods can help address knowledge gaps regarding potential sources of PFASs in this particular drinking water aquifer and evaluate risk of exposure to human health.

Toxicology
Groundwater Pathways – GW, SW, SED, Soil, ATM
Receptors Impacted
Types of PFAS onsite

Two commonly cited PFAS compounds have the following behavior:
Perfluorooctanoic acid (PFOA) at environmental pH is the anion perfluorooctanoate with estimated water solubility of 9,500 mg/L and negligible vapor pressure
Perfluorooooctane sulfonate (PFOS) has an estimated water solubility of 680 mg/L and negligible vapor pressure

Long-chain PFASs (PFHxS,PFOS, PFOA, and PFNA) more in groundwater

Short-chain compounds (PFHpAand PFBS) more in surface waters.


Poly- and Perfluoroalkyl Substances (PFAS)
Perfluoroalkyl substances
Polyfluoroalkyl substances
Polymers
Perfluoroalkyl acids (PFAAs)
Fluorotelomer-based compounds
Perfluorinated carboxylic acids (PFCAs)
Perfluoroalkane sulfonamido derivatives
Perfluorinated sulfonic acids (PFSAs)
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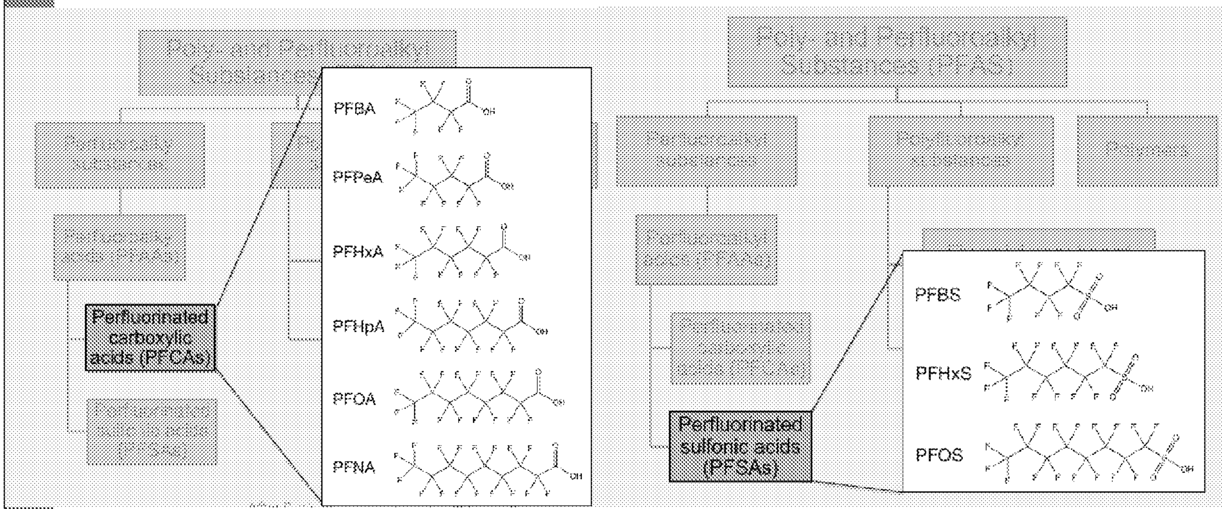
Perflourinated Compounds



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Site Assessment Specifics

- Where is the PFAS contamination coming from?
  - EPA identified the use of PFAS containing *Fumetrol* 140 and chromium tetrafluoroborate use at two electroplating facilities.
  - EPA and Delaware's DHSS identified PFAS in three public wells near two adjacent industrial plating facilities.
  - EPA identified PFAS contamination in 9 of 50 residential wells.
  - EPA is currently conducting an SI to determine the source(s) of the PFAS contamination.
    - The contamination from both facilities may be comingled - PFAS, chromium, and cyanide.
  - Both facilities used multiple types of plating processes.
  - Chromium and cyanide identified in several residential wells.

-In particular, there is still considerable uncertainty regarding human health impacts of PFASs.
-This site-wide case study illustrates how geospatial and standard investigatory methods can help address knowledge gaps regarding potential sources of PFASs in this particular drinking water aquifer and evaluate risk of exposure to human health.

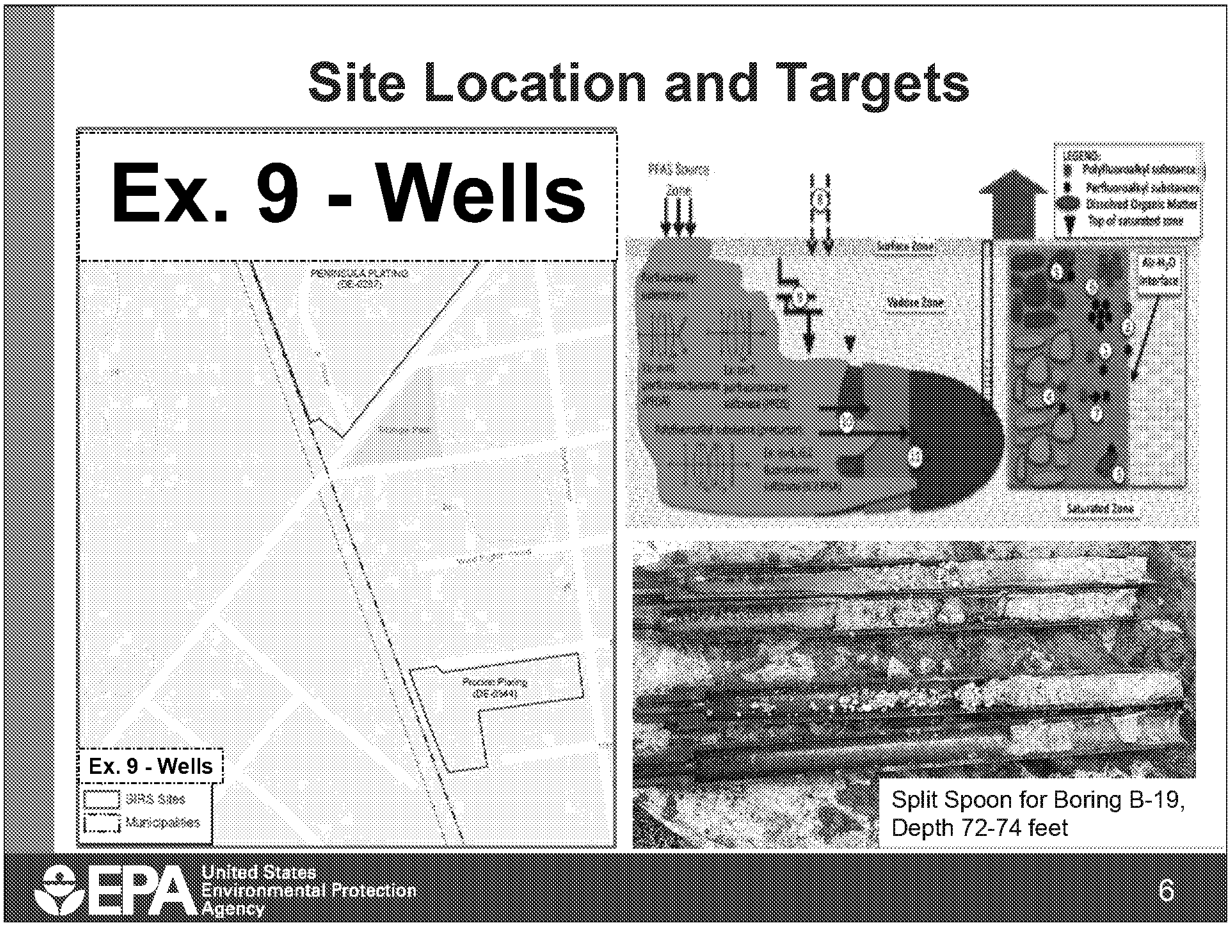
Site Location and Targets

- Sample Results
  - Three wells had results exceeding the combined PFOA/PFOS HAL.
    - Drinking Water - 193.0, 117.5, and 96.2 (ppt)
  - Nine residential wells had concentrations above the HAL. Delaware installed treatment for the these residential wells.
    - One residential well had a concentration of 364 ppt.
- EPA still conducting assessment of the groundwater plume.
  - Known contamination of the groundwater and soil
  - Threats to the surface water (human food chain, wetlands)
  - Inadequate controls and no remediation of groundwater to date
  - Abundant potential source soils at the two facilities

Stakeholder engagement is needed to ensure all of the parities understand the exposure pathways, and the sub-set of PFAS compounds in question.

To understand the release(s) I had to identify the migration methods, flow directions, sources, lithology, pumping data.
-PFASs are environmentally persistent with no significant natural pathways for complete degradation following a release or discharge.
-PFAS characteristics include being thermally stability, chemically stable, surfactant flow behavior, and stain-resistant properties
-Conventional water-treatment techniques do not fully mitigate exposure
-The final incomplete degradation products of polyfluoroalkyl substances include other PFAAs including (PFOA) if not treated with carbon.

When regulating in the low ppt level, I would propose that understanding potential sources of background in samples is also key to differentiating between PFAS-affected drinking water and cross-contamination of samples. Therefore rinsate blank and field blank samples are required.



Sampling and Analytical Issues for Site Characterization

• Limited sampling location to characterize sites – Therefore EPA had to install additional wells and collect more data.

• Sampling approach and equipment not evaluated for PFAS in all cases – EPA collects field and rinsate blanks off anything in contact with the sample.

• Many PFAS-products have varying formulations, chemistries, therefore EPA had to review SDS's for each type of electroplating fluid and method.

• Lengthy time in environment can result in transformations – EPA had to review the geochemistry and transformation products and flow data.

• Co-contaminants present but not sampled simultaneously – EPA expanded the list of analytes to all 12 PFAS compounds available to the Lab.

• Any offsite Remediation may impact PFAS concentrations and distribution to nearby wells if the remediation in incomplete.

-These frameworks to analyze the site sequentially evaluated exposure, persistence, and analysis that prioritized the PFASs for evaluation of potential human health impacts at the Blades Site.

Target - Residential Wells

Ex. 9 Wells

Coordinated with EPA’s Removal Program to quickly collect residential well samples.

Site Assessment Responses to Contamination

Response to the PFAS contamination

- Treatment system installed on the three municipal wells.
- EPA is conducting a Site Inspection
  - Well Drilling – 18 new well clusters (shallow, intermediate, deep)
  - Collected 9 comingled surface water and sediment samples to determine regional impacts
  - Collected groundwater samples
  - Review residential data from the 50 wells.
  - Review the sewer system and onsite water treatment plants
  - Investigate other facilities that may have used or use PFAS.

Knowledge gaps: Therefore additional investigation was needed…
In the general I had to get a better understanding of the composition of the type of compound onsite. So I had to gather or install additional data points.

I realized that there were more technical information that I wouldn't be able to gather at this time during the SI due to a information gap in the current research. Including partitioning, sorption, transformation, the influence of site hydrogeology/geochemistry; all of these affected my decisions in this Site Inspection.

Data and facts that were easily ascertained with environmental samples and standard hydrological methods:
Further, PFAS distribution at the field scale also depends on subsurface hydrogeologic conditions, including groundwater flow direction, velocity, and influence of heterogeneous geology. Onsite, EPA identified from previous boring logs three alternating sand/clay layers - thus becoming the zones to target from groundwater wells.

Site Assessment Strategy

- PFAS contamination response
  - Resample the Town of Blades wells
- Installed 18 new monitoring wells
  - Shallow wells - identify or eliminate source areas. (≈16 feet)
  - Intermediate wells - determine if the two facilities are comingled and determine hydrological flow direction. (≈45 feet)
  - Deep wells - determine if the facilities are comingled, regional flow/pumping direction, and cone of influence of the public wells. (≈96-105 feet)
- Sample existing wells on the Procino Plating facility to determine the extent of a release.
  - Review the method of transporting electroplating fluids through onsite water handling systems and into the sewer system.
- Review site documents and hydrology.

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Talk about well drilling and technology used for the investigation

Lessons learned from stakeholder engagement can assist in developing strategies for management of PFASs in other regions. However, current management practices primarily target a subset of PFASs for which in-depth studies are available. Exposure to less-studied, co-occurring PFASs remains largely unaddressed. Frameworks leveraging the current state of science can be applied toward accelerating this process and reducing exposure to total PFASs in drinking water, even as research regarding health effects.

Drinking water aquifers in this case was evaluated based on transmissivity and saturated aquifer thickness in order to determine new OB well density and screen depths.

Keep in mind the travel time may be on the order of years to decades without degradation. Dilution factor i.e. distance from the sources would be the only issue to keep in mind.

Site Assessment Strategy

Ex. 9 Wells

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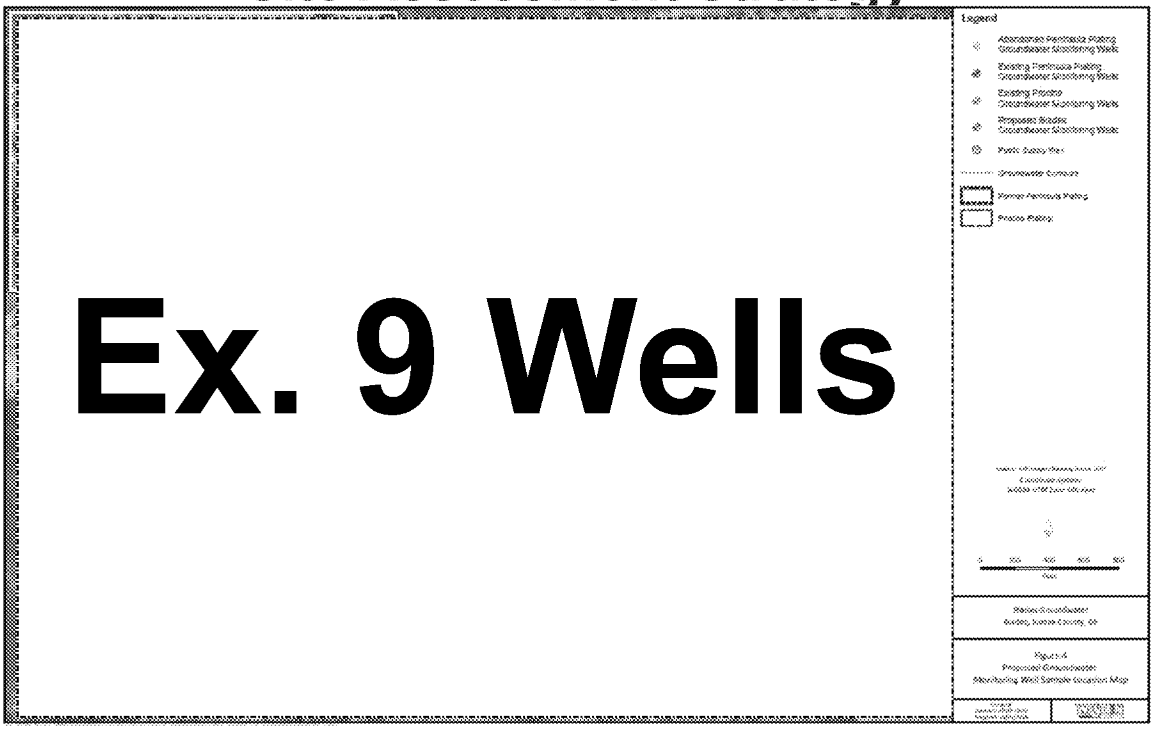
Toxicology Problems:
Address the type of PFAS which could be present because toxicology is available form only a subset of PFASs. Two different electroplating facility's had different plating methods.
Know that knowledge gaps pose challenges for regulators and other stakeholders tasked with managing PFAS releases.

Therefore EPA conducted geospatial study to identify potential PFAS source zones, modes of distribution to the groundwater, and discussions with the town of Blades to understand conduits systems and historical use of the area.

Regulations:
Values used in development of PFOA advisories and standards and associated maximum recommended levels in drinking water. USEPA value is 70ppt. DNREC assigned the state-wide value to be the same as EPA's HAL but assigned it as a hazardous substance.

Both laboratory and epidemiological studies support the potential for negative health outcomes due to PFAS exposure. In response, water quality regulations for PFASs are starting to emerge, but these regulations primarily apply to PFOS/PFOA. Regulatory levels are based solely on extrapolation from mechanistic studies in animal models and incorporate substantial uncertainty factors as a margin of safety. Therefore the town of Blades water treatment system is overdesigned and EPA installed treatment for the residential wells even though the levels in the wells are slightly below the HAL in a few instances.

Site Assessment Strategy



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Talk about map…

Remediation Strategies for public wells:
Conventional treatment techniques are ineffective for removal or destruction of the full suite of PFASs present in affected water
Processes relying on in situ chemical oxidation cannot fully destroy all PFASs but can enhance oxidation of precursors to end point PFAAs
Additionally, they may destroy perfluoroalkyl carboxylates (e.g., PFOA) under some conditions but are ineffective at degrading perfluoroalkyl sulfonates (e.g., PFOS). Filtration with granular activated carbon (GAC) and anion exchange resins (AER) have been shown to remove PFOS and PFOA but may not be as effective for treatment of short chain PFAAs and precursors. Further, filtration does not achieve compound destruction, so additional treatment or disposal of spent media is required for the town.

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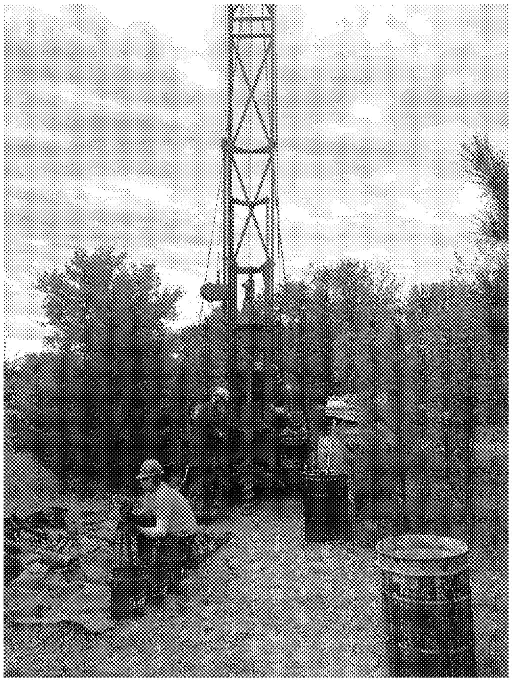
Site Assessment Photographs



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Compared with limited groundwater aquifer results, high-risk zones identified in the geospatial evaluation were proximal to drinking water wells with detectable PFAS concentrations. EPA completed academic and technical research of the geology, hydrogeology, and chemistry of Fumetrol 140 prior to the SI.

Toxicology

1) The mechanism of action for PFAA-associated toxicity is not well understood. Therefore I, consulted with EPA chemists and BTAG.

2) Although animal studies are useful in understanding the effects on the body, there are notable differences in how humans and animals interact with PFAAs. 3) PFAS have Half-lives on the order of years in humans – Therefore I did extensive geological modeling of flow times and velocities anticipating travel time without degradation could be on the order of years to decades. Fourth, the potential for synergistic toxicity is not well characterized, despite human exposure to PFAS mixtures. Therefore I consulted with ATSDR and researched academic papers.

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Photo on the left, standard auger and split spoon drilling method. I wanted to use methods which would limit the potential for cross contamination of the groundwater samples. The drillers used only steel items and standard metal tooling.

Photo on the right slit spoon to 45-47 feet sand on top with dark gray clay layer. Set the well into the sand. I attempted to obtain the best lithological controls knowing that PFAS would not sink or sorb like other organic compounds but will flow on top of the clay layers.

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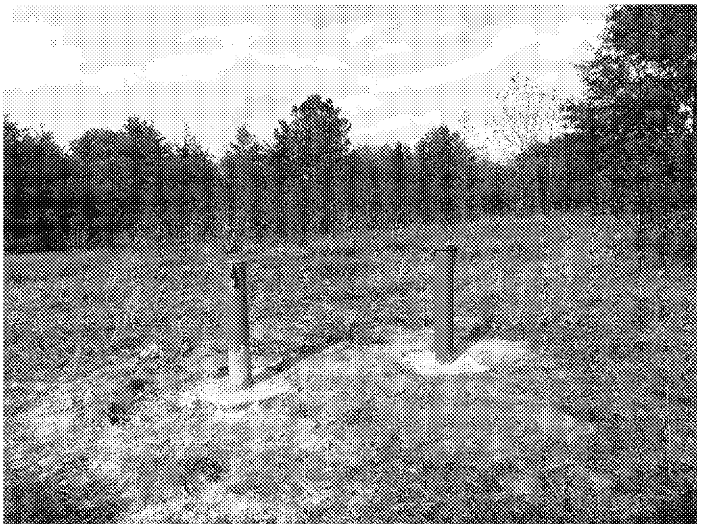
Blades Groundwater Success Story

- Cooperative Agreement between EPA and DNREC allowed for open communication identifying contamination of the public wells.
- EPA, DNREC and the Town of Blades were able to provide safe drinking water in several days to the public once the sample results were available.
- DNREC and the town installed a public treatment system in several weeks after discovery of PFAS in the public and residential water system.
- EPA's removal group samples residential wells and provided the public with treatment systems.
- EPA is currently conducting the SI in consultation with DNREC.

Site Assessment Photographs

Any Questions?



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Completed groundwater monitoring wells for the SI investigation, down gradient wells over 3000 feet from the sources.

My overall strategy took into account larger distances than typical contaminants, potential flow velocity equaling water and multiple directions. Contamination was found in the stream and sediments 3500 feet down gradient from the site. Due to the longevity of PFAs substances in the environment I had to consider long periods of time to ensure EPA's protects human health and environment.